Naval Fires Control System (NFCS) Case Study

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Objective of the Case Study

The objective of this case study is to examine how the Technical Reference Model (TRM) may be used in conjunction with the Naval Fires Control System (NFCS) to improve the interoperability of the technical, system, and operational architectures of the system. NFCS consists of the interfaces, computer resources, software, human-computer interface, and personnel required to conduct fire support operations. NFCS performs the following functions in support of Naval surface fires missions:

- Provide situational awareness by accessing and presenting the tactical picture of the area of operations;
- Prepare and disseminate fire plans from a target list
- Support the coordination and deconfliction of fire support missions with other force missions;
- Command and monitor the execution of fire missions by ownship's weapons
- Maintain and report the readiness of naval surface fires systems to perform their mission.

The TRM provides a foundation for defining a conceptual framework and a vocabulary to better coordinate the acquisition, development, and interoperability of DoD systems. This is accomplished through the definition of defined direct and logical interfaces, as well as the application of an extensive set of service definitions and relationships. This case study provides a general description of how NFCS relates to the TRM, and how the employment of the TRM can assist in the development and description of the NFCS technical architecture model. This study then illustrates the examination of a single service area in the formation of NFCS development plans.

Background

NFCS is a NAVSEA sponsored "new start" system which is being developed to provide mission planning and execution support for much of the Navy's future Land Attack mission support. NFCS will be the key mission support system for providing target information to a number of new Land Attack weapons systems including:

- Extended Range Guided Munition (ERGM) – a long range (up to 60 nautical miles) rocket-assisted, GPS-guided 5-inch artillery round.
- Land Attack Standard Missile (LASM) – a missile designed to extend Land Attack operations out to 100 nautical miles.
- Tactical Tomahawk – a modification to the Tomahawk weapons system which introduces the concept of on-station loitering as the weapon awaits assignment to target.

Rationale/Purpose

This case study illustrates a technical architecture for NFCS which was developed using the DoD TRM. The TRM provides a common conceptual framework, and defines a common vocabulary so that diverse components within

DoD can better coordinate acquisition, development, interoperability, and support of DoD information systems. The TRM technical architecture view defines services within layers.

The TRM incorporates a set of interfaces that are based on the SAE General Open Architecture model, to define the interfaces between layers. These layers share information with each other through a defined set of protocols. The TRM stack (stacked layers) begins with the physical hardware layer and proceeds through a set of layers to the application layer via a precise set of direct and logical interface definitions that clearly identify the separation of boundaries between the layers.

A layered structure provides the following attributes: layer portability, interoperability between associated layers, plug-and-play implementations, and affordability via contractor-competitive competition for the development of each of the independent layers. The TRM also defines a set of services that can be used to describe the NFCS functions associated with communications, data transfers and routing, and human computer interfaces.

Description/Process Used

The process used in this study to develop the NFCS technical arhcitecture consisted of examing written material and briefs describing NFCS, attending engineering team meetings, and analyzing the NFCS architecture data as compared to the guidance in the TRM. The key documents which were used to establish the systems current architectural status include the NFCS Operational Requirements Document (NFCS ORD), a draft of the NFCS System Specification, a draft NFCS performance specification, and numerous briefs and related Land Attack documentation.

NFCS is being developed to support Navy and Marine Corps operational concepts which require effective sea-based firepower to support sustained operations ashore and other operations in the littoral regions. The delivery of this firepower requires the development of an automated system for controlling naval fires that is:

1. compatible with the Global Command and Control System - Maritime (GCCS-M);
2. compliant with the Defense Information Infrastructure Common Operating Environment (DII COE);
3. functionally interoperable with Marine Corps Command and Control (C2) systems.

In the development of the NFCS technical architecture, a series of architectural development steps were undertaken. Figure 1 illustrates the first step which is the identification of the top level functions that must be supported to execute naval fire missions.

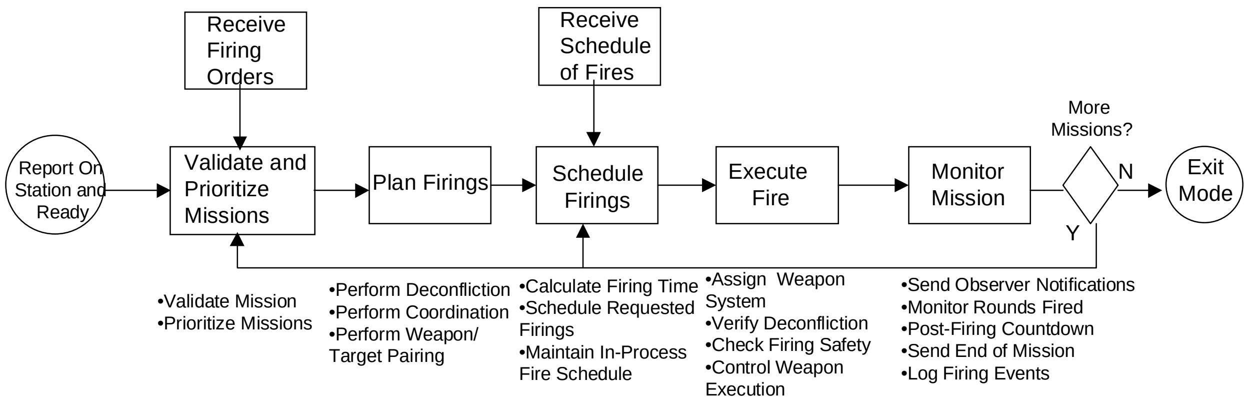

Figure 1. Top Level Naval Fires Process

From the functions illustrated in Figure 1 a set of specific functions supported by NFCS has been developed. The following diagram (Figure 2) illustrates the major functions of the NFCS system.

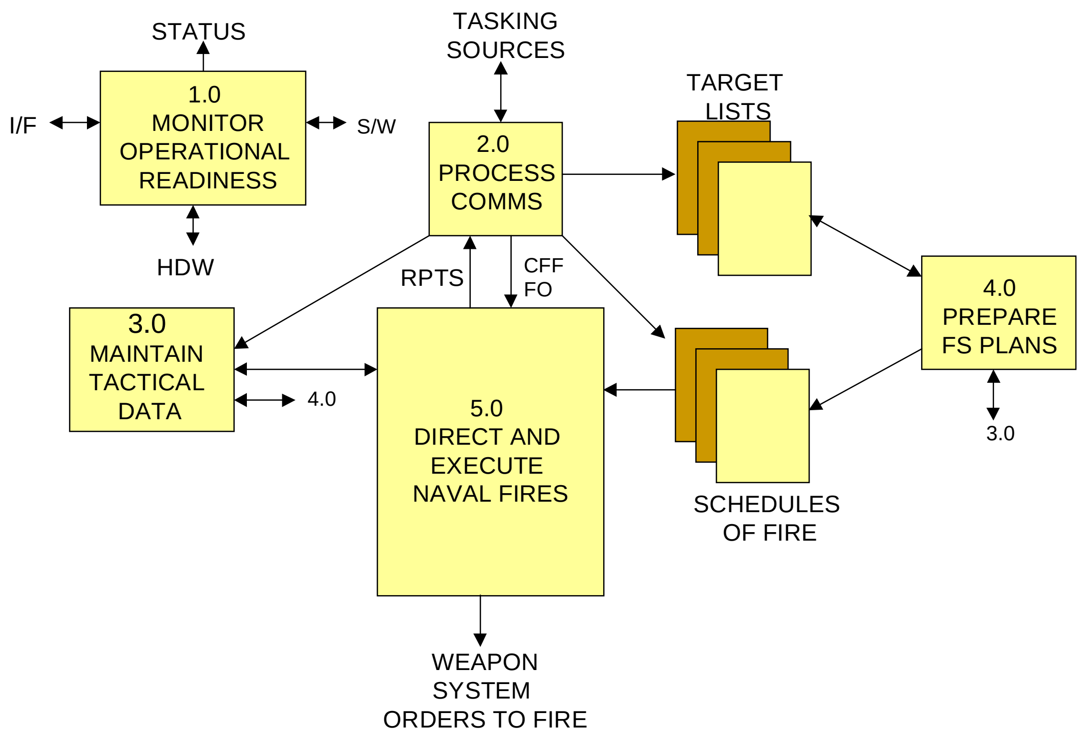

Figure 2. Major NFCS Functions

The identification of the major functions performed by NFCS coupled with a basic understanding of the interfacing operational systems has lead to a notional architecture which identifies the major components of NFCS. In the diagram below (Figure 3) the basic notional NFCS architecture is illustrated.

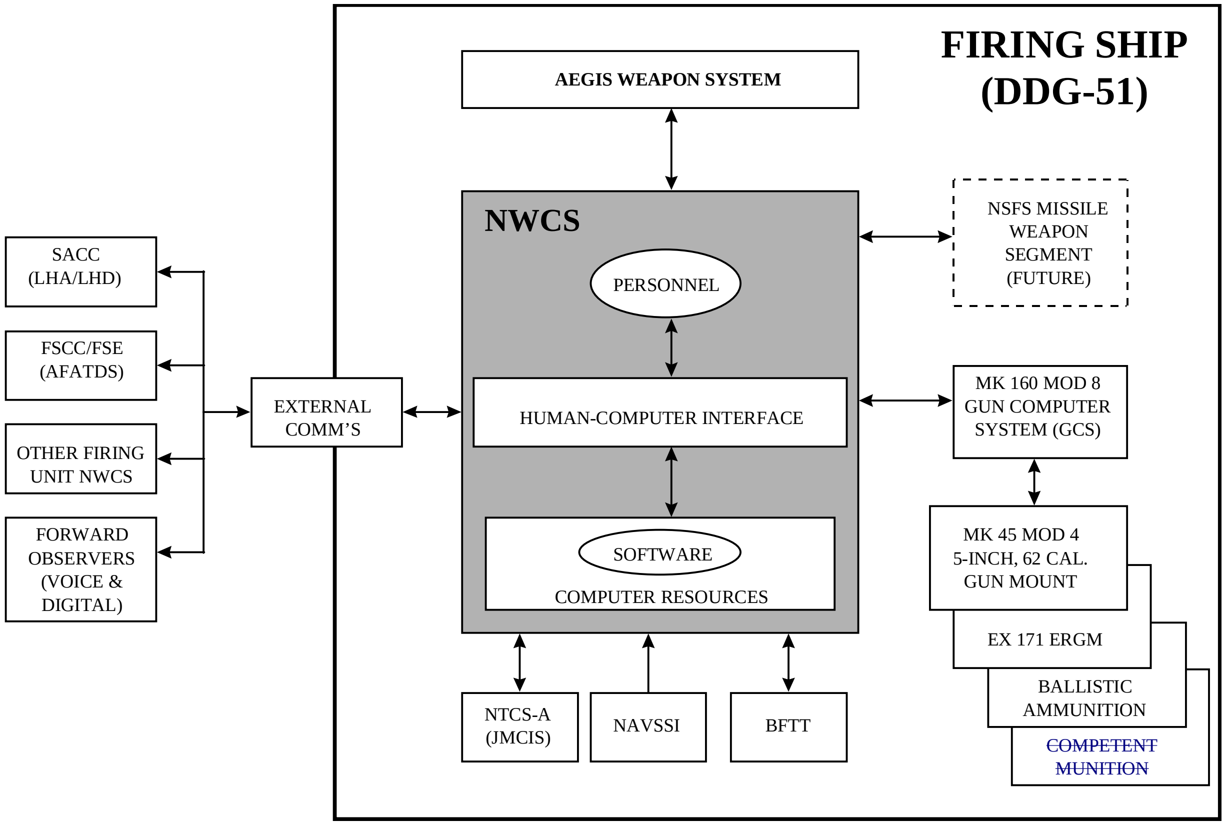

Figure 3. Notional NFCS Component Architecture

The final step is the development of a high level systems architecture for NFCS and the major systems that it interfaces with. Figure 4 is the current illustration of this high level NFCS environment architecture.

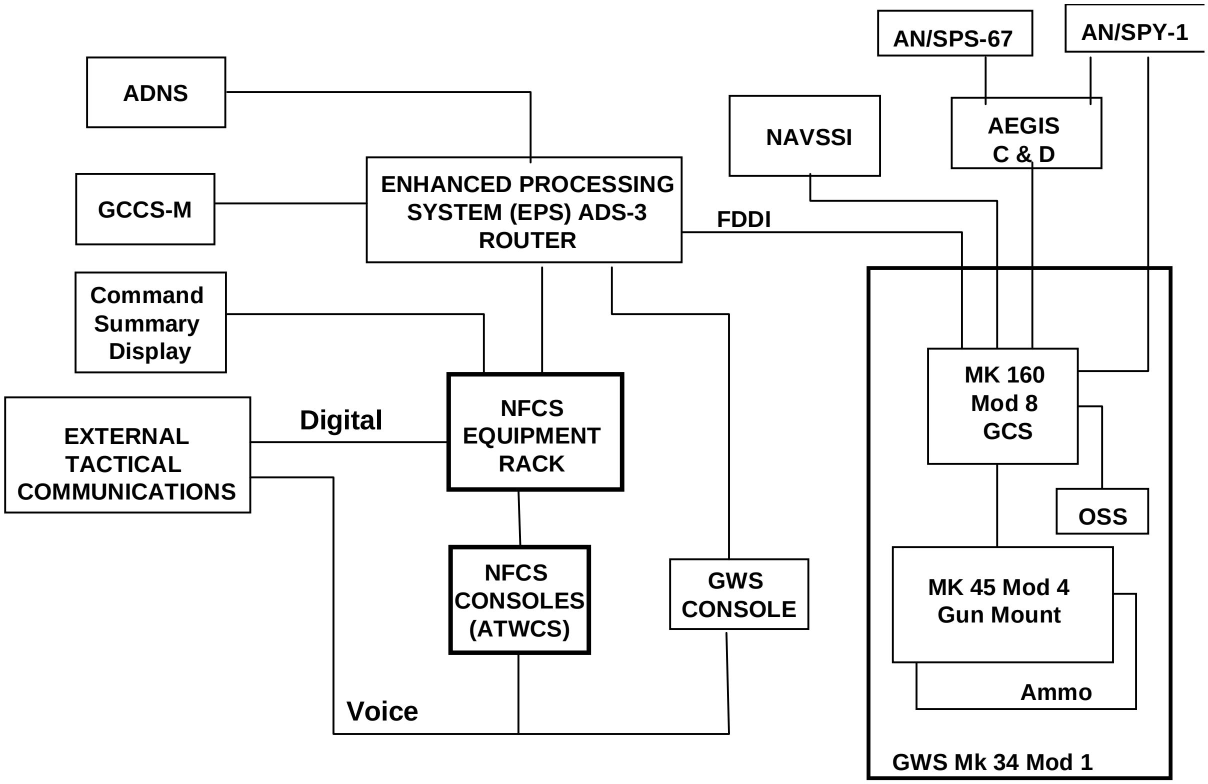

Figure 4. Phase 1 NFCS Block Diagram

It is also valuable in an examination of the NFCS architecture to understand the communcations requirements for the system. Table 1 and Table 2 summarize the message sequences and communications requirements for NFCS in Call-for-Fire sequences and general C4I coordination.

Table 1. Call-for-Fire Message Sequence

Inputs to NFCS	NFCS Processing	Outputs from NFCS
GWS Fire Control Status **GWS Gun Mount Status**	Send status report to the FO. Sends identification, reaction time, weapon type, max/min range, munitions type, and other data.	Fire Unit Status (K02.18)
Observer Status (K02.50)	Store observer identification, location and effective time.	**NFCS Spotter/Reference Point message**
Fire Support Meteorological Data (K02.3)	Establish a meteorological database, consisting of Met station locations and altitude zones. As option, enter data manually.	**NFCS Meteorological Data message**

Call-for-Fire (K02.4) GWS Target Status GWS Mission Status	Establish the Fire Mission Type, target location, target attributes file, mission time, ammunition type, and Method of Control. Order GWS to engage, evaluate fire control solution, Report "Ready."	NFCS Target Assign message **NFCS Engagement Data Message** Observer Mission Update(K02.6)(K02.14)
GWS Trajectory message Call-for-Fire (K02.4) or On-call Fire Command (K02.12)	Evaluate the deconfliction constraints. Execute the first fire. If “At my Command,” then K02.12 executes.	**NFCS Engagement Control Message**
GWS Round Fired message	Send observer notification “Shot” and “splash” reports.	Message to Observer (K02.14)(K02.6)
Subsequent Adjust (K02.22)	Store and manage adjustment data.	**NFCS Adjustment Data**
On-call Fire Command (K02.12) or Call-for-Fire (K02.4)	Execute the adjust fire	**NFCS Engagement Control Message**
GWS Round Fired message	Send observer notification “Shot” and “splash” reports.	Message to Observer (K02.14)
On-call Fire Command (K02.12) or Call-for-Fire (K02.4)	Execute the Fire for Effect	**NFCS Engagement Control Message**
Target Data (K02.9)	Used for Record As Target operation, if desired.	**NFCS Record As Target message**
Check Fire (K02.1)	Order GWS to comply with FO commands.	**NFCS Engagement Control Message**
GWS Mission Status	When rounds complete, or mission duration expired, send Break Assign and Break Engage to GWS. Report end of mission.	End of Mission Notification (K02.25), **NFCS Target Assign,** **NFCS Engagement Control Message**
End of Mission and Surveillance (K02.16)	When FO cancels mission, send Break Assign and Break Engage to GWS.	**NFCS Target Assign,** **NFCS Engagement Control Message**

Table 2. External Communications (VMF) C4I-Coordination

Inputs to NFCS	NFCS Processing	Outputs from NFCS
GWS Engagement Trajectory Data or GWS Trial Solution Response	Obtain trajectory data. Specify target number, location, weapon type, ownship location, munitions type, fuze type, and maximum ordinate.	Request for Clearance to Fire (K02.21)
Mission Clearance (K02.13)	Receive approved/dis-approved in response to K02.21 disposition action (4063 001)	N/A
Fire Support Coordination Measures (K02.15)	Display appropriate lines, areas, zones, or boundaries, and airspace coordination areas, on tactical situation display. Maintain data for use in deconfliction process.	N/A
Call-for-Fire (K02.4)	NFCS send to notify of air warning area and effective time for a pending firing. Describes location and ceiling of the area.	In Progress Mission Notification (K02.24)

A Specific NFCS Interface Example: NFCS to GCCS-M Interface

One of the essential requirements for NFCS is that the system have an effective interface with Global Command and Control System – Maritime (GCCS-M) in order to receive information on tracks and track attributes, meteorological and oceanographic information, friendly forces disposition, and air tasking orders. This interface will consist of communications and database interaction functions in the Application Support Service area to ensure that messages and track information are effectively

Interface Description

The GCCS-M Tactical Management System (TMS) a DII COE component which provides database management of tactical track data. (A track is a physical or imaginary object whose existence and, possibly, movement have been reported – i.e., "tracked".) The GCCS-M track database consists of data that includes—but is not limited to—the identifying attributes and positional histories of reported ships, submarines, aircraft, land units, and other moving or fixed objects of interest.

This key interface between NFCS and GCCS-M will use a client-server application called the Track Database Manager (Tdbm) which is designed to operate within a local area network (LAN) of computer workstations using a virtual machine architecture. A Tdbm component is run on each machine in a network. One of the machines is designated the Tdbm Master Host. GCCS-M will contain the Tdbm master. Each other Tdbm Service is designated a client on the LAN. NFCS will host a client Tdbm.

The Tdbm process running on the Tdbm Master Host machine plays the role of network controller and synchronizes the track database management activities of each Tdbm within the network. Application code logs into the client Tdbm to make database changes and/or queries. The NFCS client Tdbm maintains sufficient data in memory to answer most application queries without accessing the Tdbm Master.

GCCS-M will will also provide an interface for NFCS to receive certain data communications directly including Air Tasking Order (ATO) data and Air Coordination Order(ATO/ACO) data. This information will be received by NFCS in the form of a USMTF message via TCP/IP. GCCS-M will be set up to auto-forward the ATO/ACO messages to NFCS.

Results and Findings

The NFCS technical architecture model, illustrated in the following diagram (Figure 5), is set up as a layered TRM structure. The TRM layers define boundaries that should be used when developing NFCS computer hardware and software interfaces. The TRM abstract model helps NFCS software designers and developers recognize interfaces and modularize the software into layers. These layers are used to pass information among other components and systems.

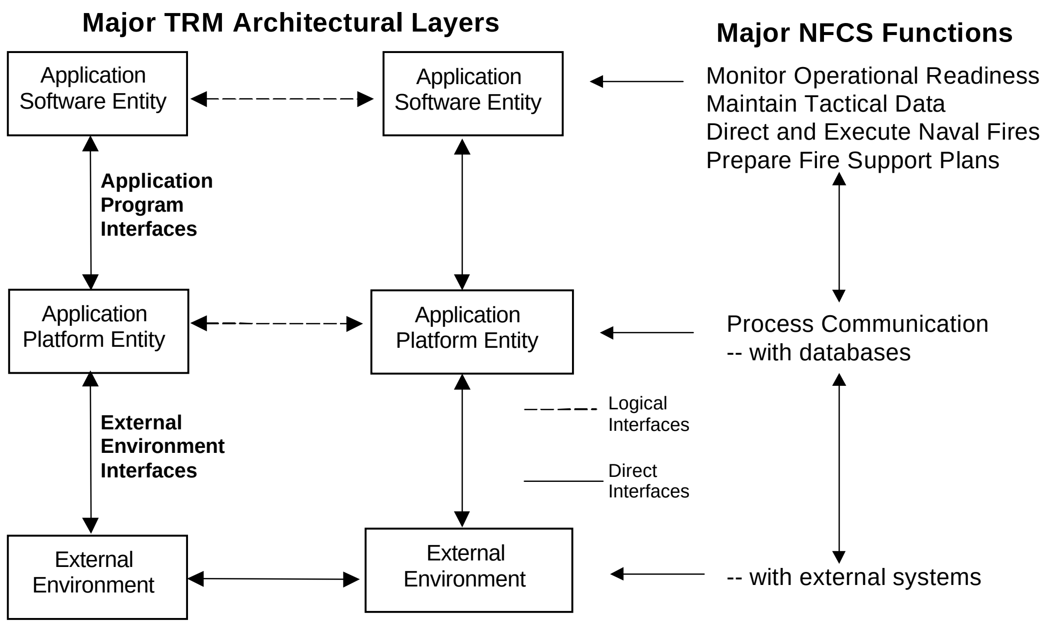

Figure 5. NFCS Functions and Layered TRM Architecture

Figure 6 illustrates the use of the TRM services view to structure the services required for NFCS. The traditional TRM services view fits the NFCS application services layer well as it provides the primary communications and support applications services required to enable NFCS to function. Additionally, the model requires little additional work other than to identify the mission support applications (user applications) that NFCS requires. The TRM services view provides an extensive checklist against which to evaluate the completeness of the final NFCS design.

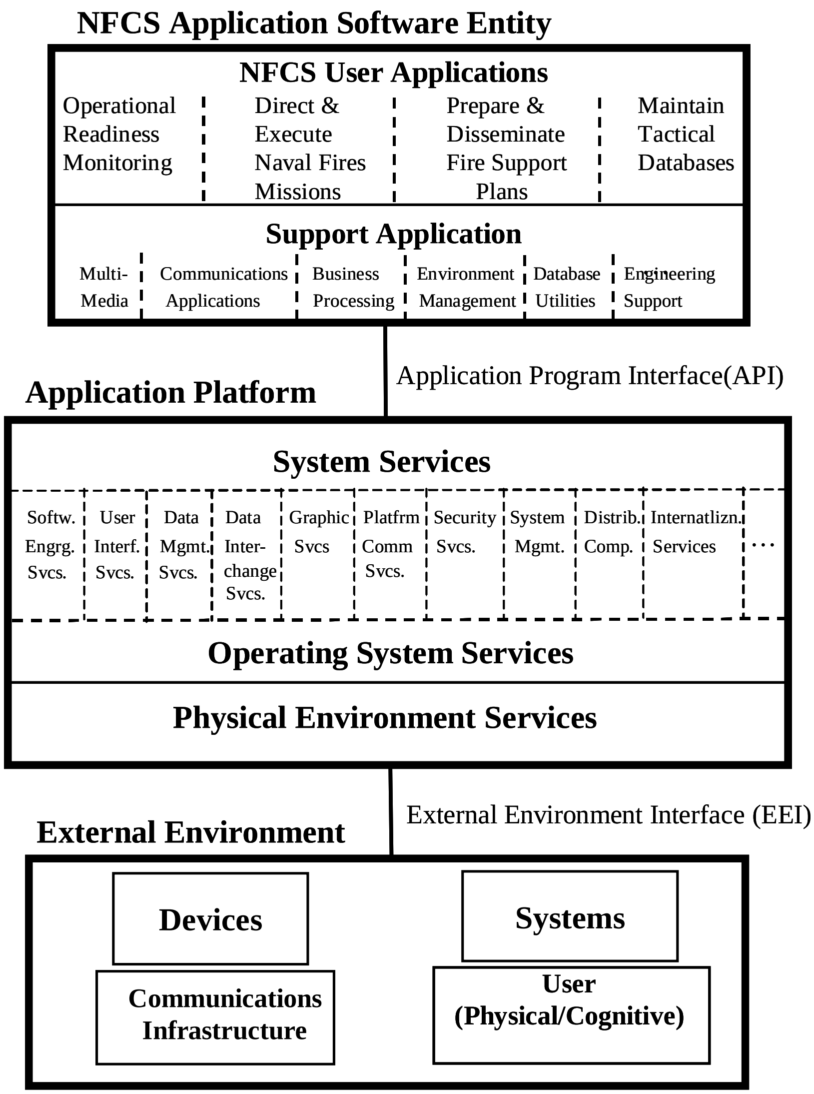

Figure 6. NFCS Services Model

NFCS to GCCS-M Interface Mappings

An interface mapping between NFCS and GCCS-M indicates involvement in all of the service areas of the model. Generally, the Application Software Entity, where User Applications operate, would stimulate an exchange of information at the application layer via database utilities executing queries, retrieving data, and storing the results. Figure 7 illustrates the primary operating components of this interface.

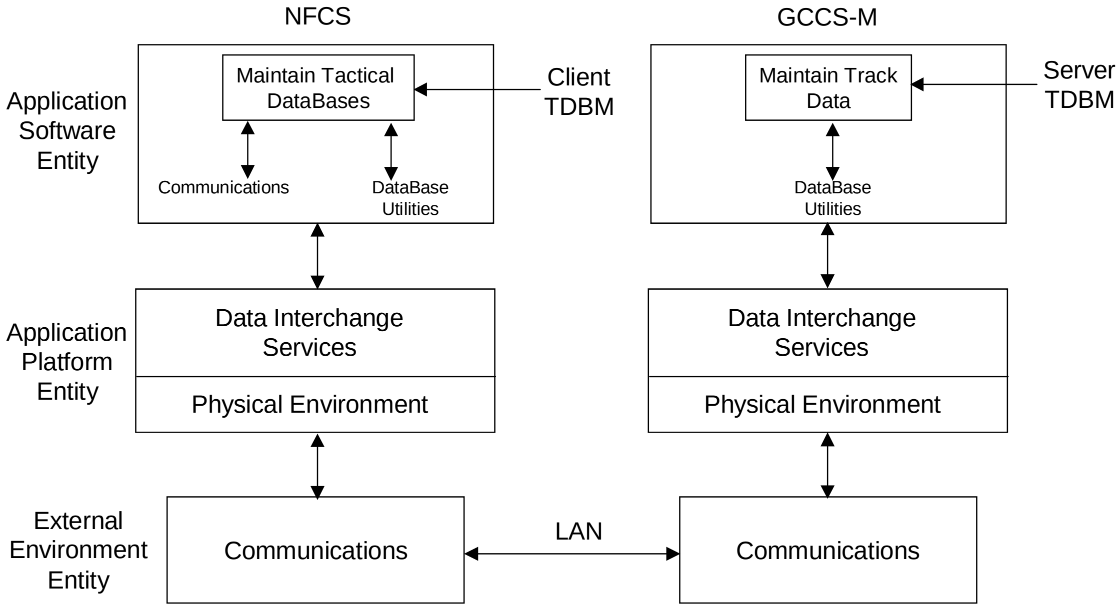

Figure 7. NFCS to GCCS-M Track Data Interface

Conclusions

The primary conclusion to be drawn from an effort to map the NFCS architecture using the TRM is that the process is relatively straightforward and potentially useful in providing reference information for standards within the NFCS development effort Contributing standards can be identified relatively easily once the interfaces have been mapped to the model. It is also believed that interoperability will be more assured considering the application of a systematic layering of functions, interfaces, services, and the use of standards.

NFCS architecture development efforts are in their early stages and significant work remains to be done. Additional effort must be undertaken to establish the applications required in more detail and to complete the mapping of services and interfaces to specific hardware, software and standards. NFCS architects are aware that significant challenges remain in establishing detailed information exchange and interface performance data.

References:

1. Operational Requirements Document for a Naval Fires Control System (ACAT III), version 3, 11 June 1999
2. Surface Combatant Land Attack Guidance Document, 30 August 1999 draft
3. Naval Surface Fire Support Concept of Employment, version 3, March 2000
4. DoD Technical Reference Model (DoD TRM), Version 1.0, 5 November 1999
5. DoD Joint Technical Architecture, Version 3.0, 15 November 1999
6. NSFS Mission Need Statement, May 1992

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